A systematic review of changes in women's physical activity before and during pregnancy and the postnatal period

Marzieh Abbasi[a] and Olga van den Akker[b]

[A] Corresponding Author: Ultrasound Department, Queen Charlotte's & Chelsea Hospital, Imperial College NHS Trust, London W12 0HS Email: marzy.abbasi@yahoo.co.uk

[b] Department of Psychology, Middlesex University, The Burroughs, London NW4 4BT

Short Title: Systematic review of physical activity in pregnancy

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Abstract

Objectives: to determine the magnitude and type of regular physical activity changes in women around the time of pregnancy. **Background:** This systematic review synthesizes the results of studies examining regular physical activity in women before they become pregnant and the magnitude and type of changes during pregnancy and the post natal period. **Methods:** Electronic data bases were searched for relevant articles and PRISMA guidelines for selection of articles were used. Only studies looking at naturally occurring, non intervention changes in regular activity levels were included. The quality assessment was based on protocols of the Cochrane Database of Systematic Reviews. Of the initial 720 titles, 24 studies which met the inclusion criteria of being non intervention studies were included in the final review. **Results:** Compared to pre pregnancy, the magnitude of physical activity decreased over the course of pregnancy and post natally and the types of activities tended to be of lesser intensity than pre pregnancy. The quality of the research was varied, methodological limitations included using subjective methods of assessment of physical activity (9/24), failing to report reliabilities or validity of measures used (8/24), no information on parity (13/24) or level of fitness prior to pregnancy (11/24). **Conclusion:** The evidence suggests a marked decrease in the amount and type of moderate to strenuous physical activity during the transition to motherhood, which does not always increase again in the post partum. Patient education targeting specific physical activities at regular intervals during and after pregnancy to improve long term maternal health is necessary.

Introduction

The public health benefits of physical exercise as an effective means of achieving or maintaining weight control, balancing mood and enhancing self-esteem are well evidenced (Warburton et al, 2006). Despite this, increasing proportions of populations in developed (Haskell, Blair & Hill, 2009) and developing countries (Pasquali et al, 2007) are failing to adhere to recommended levels of daily physical activity, contributing to the global increase in obesity levels and associated morbidity and mortality. The tendency to reduce physical activity levels has also been identified in women of reproductive age and this may have a negative effect on their ability to conceive (Wise et al, 2010). For example, a high body mass index (BMI), overweight and obesity each account for poor reproductive health outcomes (Awartani et al, 2009); including early pregnancy loss (Bellver et al, 2010) and congenital abnormalities (Stothard et al, 2009).

In addition to being an important factor in determining body weight and fertility, encouragement of physical exercise during and after pregnancy may be instrumental in preventing obesity in growing families (van den Akker, 2012). To this end, the American College of Obstetricians and Gynaecologists has also suggested that pregnant women take moderate exercise at least three times a week in order to promote maternal health and fitness (ACOG, 2002). This has been endorsed by the Royal College of Obstetrics and Gynaecology (RCOG, 2006). Although well recognized as beneficial, little attention has been paid to the changes in lifestyle behaviours which occur in women during the pre pregnancy to pregnancy and post natal phases (Gaston and Cramp, 2011), with women continuing to reduce their physical activities during pregnancy (Mottola, 2002; Brown and Trost, 2003; Poudevigne and O'Connor, 2006). The extent to which perinatal health behaviours are influenced by habits prior to conception, or the degree to which improved lifestyle habits can be introduced

following birth, are still relatively understudied (Abbasi et al, 2014). Specifically, little has been documented about the non-intervention changes (amount and type) of physical exercise habits in women as they transition from before pregnancy to pregnancy and into the post natal period following pregnancy.

In order to formulate appropriate interventions or health promotion campaigns in the future, it is important to synthesise the results of available studies investigating these non-intervention changes in physical activity among expectant mothers. A continuous review of the topic is important to provide an update on the recent and changing evidence concerning the type, intensity and frequency of non-intervention changes in physical activity before, throughout and after pregnancy. The aims of this systematic review are therefore to build upon previous reviews (Poudevigne and O'Connor, 2006; Gaston and Cramp, 2011) and synthesize the relevant research investigating non-intervention changes in physical activity in women before, during and after pregnancy. Previous reviews focused on psychological correlates and predictors of physical activity during pregnancy respectively (Poudevigne and O'Connor, 2006; Gaston and Cramp, 2011). Specifically, our focus is on the quality of the research in relation to changes in the magnitude and changes in the type of physical activity.

Methods

The PRISMA guidelines (Liberati, *et al*, 2009) were used in the reporting of the review and the *Cochrane handbook for systematic reviews of non-randomized* studies (adapted by Green, 2004) was used to assess the quality of the studies included in the systematic review. The outcome measures were changes in physical activity type and amount from pre pregnancy to pregnancy and / or from pre pregnancy or pregnancy to post delivery.

Identifying research

A comprehensive literature review of the published literature was undertaken to identify relevant studies. The electronic databases of MEDLINE, EMBASE *and* PsyINFO, British Nursing Index, CINAHL and Science direct were searched and the citation list of relevant review articles and included papers were also searched. An initial scoping search was performed using PICO (Booth et al, 2000) to identify key words and Mesh headings relevant to physical activity and pregnancy. The keywords: preconception, prenatal, perinatal, antenatal, pregnancy, gestation, pregnancy trimester, postnatal, postpartum, term, motor activity, recreation, physical activity, occupational activity, exercise, aerobic, leisure physical activity, fitness, change, fluctuation and alterations were used in all possible combinations. In addition a bibliographic search of all the included studies was performed to identify any additional literature. The searches were undertaken in early December 2012 and a second search, updating the existing review was conducted in November 2014. All titles (n=5303) from the search results were checked by both authors (MA and OA) for duplicates, studies using interventions and non-English papers. The remaining (n=790) titles and abstracts were then screened by both authors. Of those, (n=560) full text papers were retrieved for further eligibility consideration. Of the 560 full texts, 24 met the inclusion criteria and were included.

Study selection

All papers were screened using the title (based on PRISMA guidelines) to remove papers which did not meet the inclusion criteria; were in a language other than English or were duplicate papers. The remaining papers were reviewed by title and abstract to identify in more detail those that met the inclusion criteria.

Inclusion criteria were:

- Language: Articles had to be in English, since translation services were unavailable.
- Type of participants: Women regardless of parity, age, education, race, culture, ethnicity and living with or without partners.
- Design: Observational studies including cohort, descriptive and cross sectional studies such as surveys. This review also considered qualitative studies.
- Types of outcome: The outcome measures were changes in physical activity type and amount from pre pregnancy to pregnancy and / or from pre pregnancy or pregnancy to post delivery. Both positive, negative and no changes in physical activity were looked for.

Exclusion criteria included:

- Language: Non English publications.
- Type of participants: Men or women not pregnant or in the post natal period.
- Design: Randomized-controlled trials and other experimental interventions were purposefully excluded since the primary aim of this systematic review concerned whether behaviours changed naturally before, during and after pregnancy, not whether lifestyles can be improved experimentally.
- Types of outcome: Levels or types of physical activity at only one point in time, and where no change is measured.

Data extraction

The study selection process following PRISMA guidelines is shown in the flow diagram (Figure 1). Of the 5303 titles initially identified, 790 abstracts were read. Of the 790 abstracts, 560 full texts were read and 536 were excluded because they failed to meet the inclusion criteria. The full text of the remaining 26 studies was screened by the first author (MA) and cross-checked by the second author (OA) to ensure they met the

inclusion/exclusion criteria. Of the full text papers, 26 studies meeting the inclusion criteria were further reduced. Two papers (Clarke & Gross, 2004 and Rousham et al 2006) were excluded because they reported on the same data set, and their third (2005) paper reported primary data on physical activity and relevant measures. A total of 24 studies were therefore included in the systematic review.

A data extraction sheet was used to collect relevant information about the studies (Green, 2004). Data was extracted from relevant articles (MA) and cross - checked (by OA).

Quality assessment

The quality of each of the 24 studies was assessed using the criteria outlined in the Cochrane Handbook for Systematic Reviews of non-randomized studies. The criteria were adjusted (Green, 2004). to fit the remit of this review:

1. Outcome measures: the outcome measures were defined in terms of physical activity and described preferably including reliability and validity coefficients for quantitative studies and research questions for qualitative studies.
2. Study methodology: study methodology was clearly described, with clear participant recruitment and selection procedures, a sufficient sample size and description of participants. The method and time of assessment and outcome measurements should also be clearly stated.
3. Study population representativeness, attrition rates.
4. Validated measures, (statistical / qualitative) analysis appropriately described.

Based on Green's (2004) data extraction sheet, we evaluated the quality of quantitative studies giving points (+1 – yes, 0 – unclear, -1 – no) for specific criteria:

a) adequate sample size (a minimum of 30 participants in quantitative studies)

b) representative of study population,

c) low attrition (below 30%)

d) used mostly validated measures (standardized, with data on validity and reliability) (not for qualitative studies)

e) appropriate timing of measures (length of time)

f) measures which were consistent with aims

g) conclusions which were consistent with results

h) methodology which was clear

i) and (statistical) analysis which was clear and correct.

Using this model we evaluated the quality of the research using a points system (1 = yes, 0 = unclear, -1 = no) to evaluate specific criteria. The maximum score a study could achieve is 9; the minimum 0. We adapted the same evaluation grid for the qualitative study quality rating. The rating point system was the same except that we omited specific criteria as they were not available for qualitative studies (e.g.data on reliability and validity of questionnaires). The maximum score for qualitative studies was +8 and the minimum 0. The authors independently assessed the quality of each study. Disagreements concerning extracted data were resolved by consensus.

Results

Details of the selected papers' data extracted and the quality ratings attributed to them, are summarized in Table 1. All studies were carried out in developed countries, dates of publication ranged from 1995 to 2011. The majority were conducted either in the USA (n=11) or the UK (n=3), three in Canada and in Australia, Two in Norway, one each in Sweden and Switzerland. Nineteen were prospective studies, five were retrospective studies

of primary or secondary data. The prospective studies included 16 longitudinal cohort studies (Borodulin et al, 2009; Chasan-Taber et al, 2009; Clarke et al, 2005; Cramp and Bray, 2009; Duncombe et al, 2009; Fell et al, 2009; Goodwin et al, 2000; Hausenblas et al 2008; 2011; Lof and Forsum, 2006; Melzer et al, 2009; Owe et al, 2009; Pereira et al, 2007; Poudevigne and Connor, 2005; Sternfeld et al, 1995; Treuth et al, 2005), and 3 cross sectional studies using prospective questions (Hinton et al, 2001; McParlin et al, 2010; Schmidt et al, 2006). The retrospective studies included 2 cross sectional studies asking for retrospective recollections of physical activity (Cioffi et al, 2010; Haakstad et al, 2007), 2 retrospective recall questions in cohort studies (Symons-Downs and Hausenblas, 2004; Waellens et al, 2003) and 1 secondary analysis (Mottola and Campbell, 2003).

Changes in physical activity

Only one retrospective study included the postnatal period (Symons Downs & Hausenblas 2004). Overall, the results from the retrospective, cross sectional and secondary analysis studies document decreases in physical activity associated with pregnancy (e.g. Haakstad et al 2007) and decreases in the post natal period (e.g. Symons Downs and Hausenblas, 2004). The large retrospective secondary analysis study by Mottola and Campbell (2003) surveyed 529 women to identify whether forms of both structured and recreational activity patterns changed from pre-pregnancy to during the pregnancy. While there was a reduction in all categories of structural and recreational activities; walking was a popular leisure activity in late pregnancy (Mottola and Campbell, 2003), as were household and caregiving activities, but occupational activities decreased with increasing term of pregnancy (Schmidt et al, 2006). Vigorous exercise decreased from before to during pregnancy (Waellens et al, 2003) and picked up only slightly post partum (Symons Downs and Hausenblas, 2004). A reduction in moderate activity in pregnancy, reducing further post partum was also reported (Symons

Downs and Hausenblas, 2004). Mild exercise also decreased pregnancy (Cioffi et al, 2010) and again post partum (Symons Downs and Hausenblas, 2004). Weallens, *et al*, (2003) recorded the exercise behaviours of recently delivered primiparous women. Compared to pregnancy, their pre pregnancy adulthood physical activity consisted of competitive team sports, whereas, walking, swimming and yoga were more likely to be undertaken during pregnancy.

Six prospective studies assessed physical activity changes from pre pregnancy to pregnancy (Chasan-Taber et al, 2007; Duncombe et al, 2009; Fell et al, 2009; Hinton et al, 2001; Lof and Forsum, 20006; and Sternfeld et al, 1995). Eight studies (Clarke et al, 2005; Cramp and Bray, 2009; Goodwin et al, 2000; Hausenblas et al, 2008 and 2011; McParlin et al, 2010; Poudevigne and O'connor 2005; Owe et al, 2009) only considered changes across the trimesters of pregnancy. Five studies (Borodulin et al, 2009; Melzer et al, 2009; Pereira et al, 2007; Symons-Downs and Hausenblas, 2004; Treuth et al, 2005) included the post natal period, ranging from 5 months (Symons-Downs and Hausenblas, 2004) to 12 months post partum (Borodulin et al, 2009).

The results of the prospective studies are generally consistent with the findings from the retrospective and cohort/ secondary analysis studies. Changes in barriers to physical activity (Cramp and Bray, 2009), intentions (Hausenblas et al, 2008) and changes in levels of physical activity are reported in most (Borodulin et al, 2009; Chasan-Taber et al, 2007; Clarke et al, 2005; Goodwin et al, 2000; Hausenblas et al 2011; Hinton et al, 2001 (previously exercising women only); Lof and Forsum, 2006; McParlin et al, 2010; Melzer et al, 2009; Owe et al, 2009; Pereira et al, 2007; Poudevigne & O'connor, 2005; Sternfeld et al, 1995; Symons-Downs and Hausenblas, 2004) but not all (Hinton et al, 2001 (sedentary

women only); Treuth et al, 2005) studies. Those who did, showed a reduction in levels of physical activity during pregnancy compared to before and/ or after pregnancy. According to Lof and Forsum (2006) and McParlin et al (2010) the decrease in physical activity levels are more pronounced in later than early pregnancy.

There was a slight discrepancy in the pattern of postnatal physical activity reported by the prospective studies. For example, Melzer et al (2009) and Treuth et al (2005) showed a recovery in levels of physical activity and fitness in the first half of the year postpartum. Borodulin et al (2009) also reported an increase in physical activity at 3 months post-partum, which remained stable at 12 months post partum. In contrast, Pereira et al's study of more than 1400 pregnant women, found that the reduction in physical activity during pregnancy persisted at 6 months postpartum (Pereira *et al*, 2007).

There is little information concerning levels of regular physical activity in pregnant women who are overweight or obese, despite the fact that these women would stand to benefit most from interventions to promote physical activity, due to the increased risk of adverse outcomes in many overweight women. Of the 24 studies reviewed, 12 studies noted the participants' BMI. Only one study objectively tested and compared the duration and intensity of physical excise in overweight and obese women in the early and late stages of pregnancy (McParlin et al, 2010). There was no significant difference in levels of physical activity between overweight and obese women who continued to adhere to the recommended levels of physical activity during pregnancy. The relatively small sample size, however, limited the ability to gauge accurately what differences existed between overweight and obese women. Fell et al (2009), using questionnaires, reported a 66% continuation in women with a BMI of <25; 21% continuation in women with a BMI of 25-29; and a 12% continuation in women

with a BMI of >30 from pre pregnancy into the 20th week of pregnancy. Treuth et al, (2005) also measured pregnancy-related changes in physical fitness and exercise in women who had low, normal and high BMI prior to pregnancy. In contrast to Fell et al, Treuth's low-BMI groups' levels of physical activity was lower postpartum than they had been pre-pregnancy, while no significant differences were reported in the normal and high BMI groups (Treuth et al, 2005), and Chasan-Taber et al (2007), reported an inverse relationship between pre pregnancy BMI and active living behaviours in mid pregnancy. With the exception of Chasan-Taber er al (2007), these findings are limited by small sample sizes.

Types of physical activity

Across all studies, there was a general tendency to engage more in light intensity activities such as relaxation, walking and household / caregiving activities throughout pregnancy (Borodulin et al, 2009; Chasan-Taber et al, 2007; Clarke *et al*, 2005; Duncombe et al, 2009; Hausenblas et al, 2011; Lof and Forsum, 2006; McParlin et al, 2010; Mottola and Campbell, 2003; Pereira *et al*, 2007; Poudevigne and Connor, 2005; Schmidt et al, 2006; Symons Downs and Hausenblas, 2004; Treuth *et al*, 2005; Weallens et al, 2003). This striking absence in moderate to vigorous activity is of concern. Sternfeld et al, (1995) even reported an increase in sedentary activities over the course of pregnancy. However, although Owe et al (2009) also reported decreases in most less intense activities, they reported an increase in swimming from pre pregnancy to T3. Fell et al, (2009), Haakstad et al, (2007) and Mottola and Campbell (2003) reported an equivalent decrease in sport and exercise, and McParlin et al (2010), Pereira et al, (2007), Poudevigne and Connor (2005), Sternfeld et al, (1995) and Symons Downs and Hausenblas (2004) a decrease in vigorous exercise from pre pregnancy or trimester 1 to T2 and T3.

Borodulin et al (2009) charted details of the proportion and types of different physical activities in 47 pregnant and post natal women. They found a decrease in occupational and outdoor household physical activities at 12 months post partum and an increase in indoor household and care giving activities. McParlin and colleagues (2010) also reported an increase in self-reported physical activity energy expenditure (PAEE) attributed to activity at home (including childcare) between the first and third trimesters and a corresponding reduction in work-related PAEE. Conversely, Clarke et al (2005) observed that self-reported PAEE relating to domestic activities remained static throughout pregnancy although they too reported occupational activity decreased. Clarke et al's (2005) participants were all women in their first pregnancy, perhaps explaining the lack of increase in domestic PEE. Contrary to McParlin and Clarke above, Borodulin et al (2009) reported an increase in recreational and a decrease in household activity during pregnancy. Increasing barriers to leisure time physical activity in pregnancy (Cramp and Bray, 2009; Symons Downs and Hausenblas, 2004) were also reported. Most of these changes reflect changes in job and carer status. However, nothing was known about these women's pre pregnancy and in Clarke et al and Cramp and Bray's studies also the post partum physical activities limiting the ability to determine change from pre pregnancy. Although most of the more vigorous and sport physical activity did not return to pre-pregnancy levels in the post partum, a return to mild activities such as walking and home activities post partum has been reported (Pereira et al, 2007; Treuth et al, 2005).

Quality of the research

Quality scores: As can be seen in the final column in Table 1, of the 24 studies included in this systematic review, the quality of four studies reached the highest quality score of '9' (Chasan-Taber et al, 2007; Fell et al, 2009; Owe et al, 2009; Pereira et al, 2007), six received an '8' (Borodulin et al, 2009; Haakstad et al, 2007; Hausenblas et al, 2011; Hinton et al,

2001; Schmid et al 2006; Treuth et al, 2005) ten a '7' (Cramp & Bray, 2009; Duncombe et al, 2009; Goodwin et al, 2000; Hausenblas et al, 2008; Lof and Forsum 2006; McParlin et al, 2010; Melzer et al, 2009; Poudevigne and Connor, 2005; Strenfeld et al, 1995; Symons Downs and Hausenblas, 2004). Only 1 study received a quality score of '6' (Clarke et al, 2005) and three received a '5', the lowest rated quality studies (Cioffi et al, 2010; Mottola & Campbell, 2003; Weallens et al, 2003). No study scored below 5, suggesting the research included was of adequate to good quality and none were of poor or questionable quality.

Method of measurement: In recent years, objective methods for measurement of physical activity such as accelerometry, which have a high degree of validity for quantifying activity intensity and duration, have become available. Few studies have used these or other objective methods to measure activity changes in association before and during pregnancy (Lof and Forsum, 2006) during pregnancy (McParlin et al, 2010; Poudevigne & O'Connor, 2005) and during pregnancy into the post partum (Melzer *et al*, 2009). One study assessed changes in physical activity pre-pregnancy during and post pregnancy (Treuth et al, 2005). The objective measurements also suggest that during pregnancy light exercise was maintained, while high intensity activity declined, along with levels of physical activity, particularly in the latter stages of pregnancy, which is in line with other studies using self-report measures.

A high proportion of activities during pregnancy tend to be low intensity and less structured, consisting generally of childcare and domestic tasks, which may be less well-documented in questionnaires. Overall, 11 studies used questionnaires (Cramp and Bray, 2009; Duncombe et al, 2009; Fell et al, 2009; Haakstad et al, 2007; Hausenblas et al, 2008; Hausenblas et al, 2011; Hinton et al, 2001; Mottola and Campbell, 2003; Owe et al, 2009; Symons Downs & Hausenblas, 2004; Weallens et al, 2003), 4 used interviews (Chasan-Taber et al, 2007;Cioffi

et al, 2010; Schmid et al, 2006; Sternfeld et al, 1995); 4 used questionnaires and interview (Borodulin et al, 2009; Clarke et al, 2005; Goodwin et al, 2000; Pereira et al, 2007), 3 used questionnaires and objective measures (Lof and Forsum, 2006; McParlin et al, 2010; Treuth et al, 2005), 1 used an interview and objective measures (Poudevigne & Connor, 2005) and 1 used objective measures alone (Melzer et al, 2009) to obtain their information on changes in physical activity. The use of focused questionnaires to record the intensity, frequency and patterns of physical activity in pregnant women has undoubtedly provided detailed information, although it may be argued that the subjectivity inherent in these methods has influenced the results.

Importance of parity: Any changes in activity among parous women may be attributed, not only to the effect of pregnancy, but also to the fact that they have demands placed on them by existing children, as was reported by Chasan-Taber et al, (2007). Seven studies did not refer to parity (Hausenblas et al, 2011; Lof and Forsum, 2006; Poudevigne and Connor, 2005;; Schmid et al, 2006; Symons Downs and Hausenblas, 2004; Treuth et al, 2005; Weallens et al, 2003). Seventeen studies reviewed referred to parity (Borodulin et al, 2009; Chasan-Taber et al, 2007; Cioffi et al, 2010; Clarke et al, 2005; Cramp and Bray, 2009; Duncombe et al, 2009; Fell et al, 2009; Goodwin et al, 2000; Haakstad et al, 2007; Hausenblas et al, 2008; Hinton et al, 2001; McParlin et al, 2010; Melzer et al, 2009; Mottola and Campbell, 2003; Owe et al, 2009; Pereira et al, 2007; Sternfeld et al, 1995). With the exception of Duncombe et al 2009 and Owe et al, 2009, the majority of studies did not provide information on the number or ages of children. Consequently, it was not possible to compare the extent of changes in physical activity between first-time mothers and those with more than one child. However, one study (Pereira *et al*, 2007) reported a greater probability of lower levels of physical

activity among multiparous women, which suggest that the first child did not have a significant effect on any changes in physical activity.

Measures and Timing: One area of weakness in the evidence relating to changes in physical activity among pregnant women is the rudimentary recall methods employed (often using questionnaires), particularly during the period before pregnancy (Chasan-Taber et al, 2007; Duncombe et al, 2009; Fell et al, 2009; Haakstad et al, 2007; Hausenblas et al, 2008; Hinton et al, 2001; Lof and Forsum, 2006; Mottola and Campbell, 2003; Owe et al, 2009; Pereira et al, 2007; and Sternfeld et al, 1995; Symons Downs & Hausenblas, 2004; Treuth *et al*, 2004) and often retrospective. Of all the studies, only Lof & Forsum (2006) focused on women prior to conception. Two studies used measures for physical activity (Weallens, *et al*, 2003 & Lof & Forsum, 2006) without publishing evidence of their reliability or validity, despite the fact that it is more difficult to assess this accurately in pregnant women. Thus, the overall evidence available was obtained largely through self-report questionnaires, and research using objective measures is sparse.

Sampling: All studies were conducted in Western developed countries, the majority of the participants being middle- to upper class, well educated white women with the exception of Hinton (2001) and Chasan-Taber et al, (2007) who studied Hispanic/ latino participants. Other limitations included small sample sizes (Cioffi et al, 2010 (n=23); Lof & Forsum 2006 (n=23); Melzer et al 2009 (n=27); Pousevigne and Connor, 2005 (n=12); Waellens et al, (2003) (n=42) and volunteer participants (Kelly *et al*, 2009; Lof & Forsum 2006; and Goodwin *et al*, 2000). Indeed, only 6 studies (Chasan-Taber et al, 2007; Hinton *et al*, 2001; Cramp & Bray, 2009; Mottola & Campbell, 2003; Kelly *et al*, 2009; and Pereira *et al*, 2007) used an adequate sample size with an attrition rate of less than 30%. However, while Hinton

et al (2001) reported a relatively high response rate of (n=622; 75%), the proportion of those who chose not to participate in the research were, on the whole, significantly younger, had not been educated to the same level as those who had participated and were less likely to be married.

Discussion

The focus of this review was to summarise the literature examining changes in physical activity from pre-pregnancy to the postnatal period. Consistent with Gaston and Cramp (2011), the results indicated that mothers are at risk of inactivity. Studies which share common/consistent findings were highlighted and discussed in order to guide future research into this area. The main findings were that mild, moderate and vigorous activity and sport all decreased from trimester 1 to 2 through to trimester 3 of pregnancy, and do not usually pick up post delivery, rarely returning to pre pregnancy levels. These results indicate that inactivity during pregnancy and postpartum may place mothers at considerable risk.

The RCOG (2006) recommends not only physical exercise during pregnancy it also urges women to initiate pelvic floor exercises in the immediate postpartum period, as this may reduce the risk of future urinary incontinence. Further benefits include improved cardiovascular fitness, weight loss, improved mood and reduced anxiety and depression (Mottola, 2002) without compromising breastfeeding or infant growth (Carey & Quinn, 2001). Women need to return to pre pregnancy exercise levels gradually, not resuming high impact activity too soon. The finding that women exercise less during the first and third trimesters of a pregnancy and postpartum, is not surprising given some of the biological reasons for this - vomiting, backaches, fatigue, etc. It is also most logical that women would walk, do yoga and other exercises while pregnant to adapt to their changing shape and

consider the changing demands on their physiological resources. What is problematic is the fact that most studies reported a continuing trend of relative inactivity post delivery.

The relative paucity and limitations of research into physical activity provide a clear opportunity for future research. Hitherto, the measurement of physical activity (PA) has depended on an excessive use of self-report instrumentation, with only a small number of studies utilising more objective measures. Therefore, future research employing objective measures will provide improved and reliable and valid data, enhancing our understanding of physical activity behaviour. Type of physical activity was frequently insufficiently reported. Physical activity involves different forms of exercise and often excludes activities not associated with sport and leisure, such as housework and occupational activity. Where details were reported, indoor, household and care giving barriers, intentions and activities tended to increase during pregnancy from pre pregnancy levels whereas occupational physical activities, outdoor recreational physical activities such as walking and sport decreased over the course of pregnancy.

It is important, therefore, given the likely changes in modes of exercise that occur during and after pregnancy, that accurate measurement is achieved. In addition, although the studies were representative of a number of developed countries in the US and throughout Europe, it was not possible to obtain any comparisons of these national data. Moreover, the majority of studies focused exclusively on women. Evidence suggests that parenthood may have lifestyle changing effects on fathers as well as mothers (Abassi et al, 2014). By extension, interaction between couples, levels of mutual support and their understanding of the roles and responsibilities they maintain as parents could be instrumental in changing levels of physical activity. There are also likely to be differences in patterns of activity between first-time

mothers and those with one or more children (Sternfeld, *et al*, 1999), an issue not considered in (most) of the studies reported in this systematic review.

It is likely that the predominant socio-demographic characteristics of this population will have affected the findings and may have been different if pregnant adolescents or younger women living in urban areas had been included. Future research should focus on recruiting a more diverse sample, particularly women of lower socioeconomic and educational strata, and women of different ethnicities to adequately reflect the proportion on non exercising women in the populations studied. Even in studies where efforts have been made to recruit participants from a wide geographical area and through multiple public health units (Cramp & Bray, 2009), the eventual sample comprised primarily white, married, educated, middle-to upper class women, which clearly affects its generalisability to lower socio-economic and ethnically diverse populations. Of the remaining studies, Mottola and Campbell (2003) were unclear about how representative the sample was, due to the failure to collect any data on non-participants. Consequently, even these large studies were unable to claim their population was representative of the general population. In summary, changes in physical activity generally showed a decrease over the course of pregnancy and postnatally compared to pre-pregnancy, but the quality of the evidence is varied ranging from +5 to +9, see Table 1.

Conclusion

Women's exercise level prior to pregnancy, and how they were recruited was not always clear, and required more attention in future research. Women of different races/ethnicities, education and income levels, is essential. More qualitative studies and studies employing technology could be useful to accurately document changes in activity prior to pregnancy, over the course of pregnancy and into the post partum period. There is a particular need for

more studies showing if and how women return to physical activity postpartum. Despite the limitations, these data provide a consolidated understanding of physical activity behaviour change during pregnancy and following childbirth. While the lack of activity during and after pregnancy is not surprising, an emphasis on the benefits of physical activity should aid the development of preventive health behaviour within reproductively active populations.

Conflicts of interest

The authors declare that they have no competing interests.

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